# FEEDING AND GROWTH OF HATCHLINGS OF *GAVIALIS GANGETICUS* IN CAPTIVITY[1]

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(*With four text-figures*)

Captive feeding and growth of hatchlings and yearlings of *Gavialis gangeticus,* and effect of different seasons on these activities are described and discussed. At a minimum water temperature 22.7°C, feeding diminished considerably but never ceased in sub-tropical Indian climate. Hatchlings and yearlings grew during all the three seasons of monsoon, winter and spring-summer. Growth rate, however, was progressive only in monsoon and spring-summer. In hatchlings food consumption of 9.18% body weight/week is considered roughly as the minimum quantum for registering positive growth. Growth pattern of hatchlings and yearlings are also presented and discussed.

## INTRODUCTION

Food intake governs growth of animals. For juvenile and adult crocodilians, food intake is known to be dependent on temperature of the ambient air (Joanen and McNease 1971, McIlhenny 1935, Pooley 1971). If this is equally true for hatchlings and yearling, their growth ought also to be dependent on temperature. Availability of facilities for studying growth of early stages of *G. gangeticus* prompted observations on the effect of temperature on feeding and growth.

## MATERIAL AND METHODS

A clutch of eggs collected in April, 1976, from a nest laid on the bank of river Chambal was brought for captive rearing to hatcheries of the Crocodile Rehabilitation and Research Centre, Kukrail, Lucknow. From 60 eggs 51 hatchlings were produced, between June 5 and 12, 1976, as 9 failed to hatch.

The hatchlings were kept in wooden crates having 10-15 cm thick layer of damp sand, containing approximately 10% water by weight. After 48 hours, when the yolk sac was absorbed, 40 hatchlings were randomly divided into four batches of 10, and each batch was released into specially designed ponds (Bustard 1975). Each set comprised 10 ponds, arranged in two rows of five, separated by wire mesh (2 mm gauge) partitions, which material was used for the roof also; each pond measured 2 m square and 33 cm in depth, with one side sloping to zero. One-metre wide space around the hatchling pond was covered with sand, for basking of the young, and at the periphery shady plants (tall fan-palm, *Livistona* sp.) were planted for sheltering the shy creatures and protecting them against the heat. The hatchlings were fed on 2.5-3.0 cm long, live fish of eight species (*Chanda ranga, C. nama, Channa punctatus, Chela laubuca, Labeo bata, Puntius ticto, P. sophore, Rasbora daniconius*) and on the freshwater prawn *Macrobrachium lamarreii.*

At 70-80 cm length, the 40 hatchlings were released into two yearling ponds, of which four in two rows of two comprised a set. Each yearling pool was 4 m square and 1 m deep. The basking area around these extended up to

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1.5 m and the shady plants were more numerous. The yearlings were fed on 7.5-10.00 cm long, live fish of six species (*Channa punctatus, C. marulius, C. striatus, Labeo bata, Catla catla* and *Rasbora daniconius*).

Owing to a time lag of 10-15 days between release of hatchlings into the pond and their settling down to regular feeding, experimentation was started on July 1, 1976, with the recording of the weight of 40 hatchlings at 10 hours. From then onwards each experimental pond was stocked daily between 10-12 hours with a weighed quantity of live fish.

Weekly fish consumption was determined from data recorded at the time of cleaning of the ponds, undertaken every 3-4 days, when uneaten dead and live fish were removed. While the live fish were returned to the cleaned pond, the dead ones were weighed before being discarded. Every week, each hatchling was weighed and its total body length (TBL), from tip of snout to tip of tail, measured. From the weekly record of food consumption of the 40 hatchlings and their biomass, the mean weight of fish consumed per hatchling per week was derived.

Air temperature, relative humidity and rainfall data were obtained from the meteorological station at Amausi (Lucknow), approximately 20 km southwest of the Crocodile Rehabilitation and Research Centre, and the water temperature of the pools at a depth of approximately 30 cm was recorded at 6 hours and 16 hours.

## RESULTS

Parallel observations on food consumption and growth were recorded for only one year, from July, 1976 to June, 1977. For the next two years 1977-79, only growth was recorded, the reason being that sufficient quantities of live fish could not always be procured, and occasionally the yearling were fed on chopped pieces of large fish, purchased alive from the local market. Consequently, the amount of food provided could not be recorded accurately. Failure to sex even three-year old gharial of 175 cm mean length thwarted recording of data separately for each sex. In contrast, *Alligator mississippiensis* hatchlings even below six months old could be sexed (Chabreck and Joanen 1979).

### *Seasonal food intake of hatchlings.*

Due to their emergence at the end of summer, the hatchlings immediately encounter the monsoon. During the monsoon, from the third week of June to the last week of September, the mean food consumption per hatchling rose from 44.90 g to 110.60 g, and the mean feeding intensity ranged from 27.61 to 33.24 percent body weight per week (Table 1). In the first winter month of November, a striking decrease over that recorded for October occurred; in the three remaining winter months, December to February, its level remained low (Fig. 1). With the onset of spring in March, food consumption rose, increased during April and May, that for June being slightly lower than for May.

The feeding activity was greatest between 15 and 16 h during monsoon, 12 to 13 h during winter and 17 to 18 h during spring and summer.

Correlation of feeding intensity with temperature (Figs. 1, 2) shows that the hatchlings fed vigorously during the four monsoon and three summer months, when the temperature ranged from 17.46° (in October) to 40.19°C (in June). When, from November to February the feeding intensity was low, the temperature also was low; in March when it was moderate, the temperature had also risen (Fig. 1). From this, 17.46° to 40.19°C, emerges as the optimum range for intensive feeding.

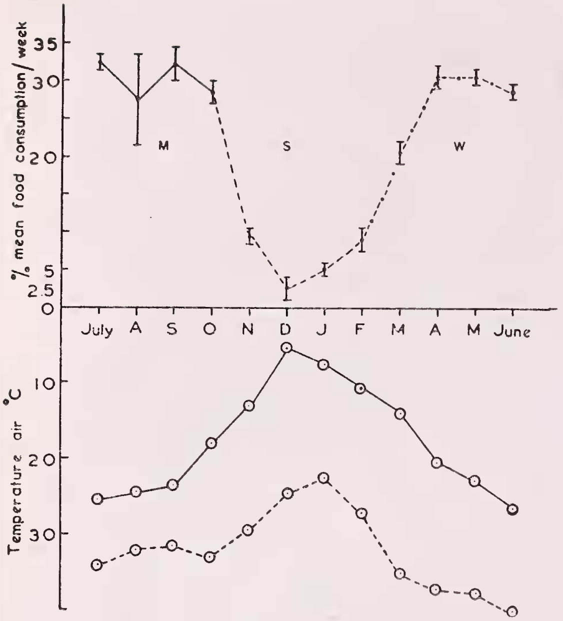

Fig. 1. Temperature-food consumption relationship of hatchlings from July, 1976 to June, 1977. Food consumption (upper half): M, monsoon; W, winter; S, summer. Temperature (lower half): maximum, broken line; minimum, continuous line.

However, the maximum feeding during summer months was recorded in May and not in June (Table 1, Fig. 1). Perhaps greater sluggishness resulting from heat stress, well known in the tropics, reduced their food intake in the hottest and driest month of June, Consequently, the mean May temperature (37.70°C), and not that of June (40.19°C), is regarded as the upper limit of the optimum range, making it 17.46°C to 37.7°C.

The wider range and lower mean of percentage feeding intensity for August than for July and September (Table 1, Fig. 1) is noteworthy. During August, the rainfall is highest and the sky variable, from heavily overcast to patchily cloudy. Consequently, greater and sudden temperature fluctuations are caused and the day temperature is generally lower due

TABLE 1

MEAN WEEKLY FOOD CONSUMPTION AND MEAN MONTHLY GROWTH PER HATCHLING FROM JULY, 1976 TO JUNE, 1977

| | Months and Seasons | Mean weight of fish consumed/ animal/week (g) | Food consumption per cent body weight/week | | 1976-77 hatchling | |
|---|---|---|---|---|---|---|
| | | | Range | Mean±S.D. | Mean weight g | Mean length cm |
| | July 1 | | | | 118.36 | 36.94 |
| | July | 44.90 | 31.35–34.10 | 33.24±1.22 | 136.36 | 45.68 |
| Monsoon, 1976 | August | 35.90 | 21.28–36.12 | 27.61±6.27 | 200.56 | 53.14 |
| | September | 84.90 | 29.40–35.00 | 32.20±2.35 | 280.86 | 56.14 |
| | October | 110.60 | 26.60–30.10 | 28.50±1.44 | 393.22 | 63.14 |
| | November | 40.20 | 8.40–10.50 | 9.45±0.90 | 510.80 | 66.37 |
| Winter, 1976–77 | December | 14.50 | 1.60– 3.50 | 2.55±1.48 | 457.50 (–53.30) | 65.42 (–0.95) |
| | January | 24.70 | 4.50– 5.86 | 5.25±0.69 | 455.23 (–2.27) | 65.33 (–0.09) |
| | February | 47.30 | 7.52–10.60 | 9.18±1.55 | 479.98 | 65.51 |
| Spring, 1977 | March | 114.40 | 19.25–21.85 | 20.77±1.32 | 516.23 | 66.78 |
| | April | 231.90 | 29.57–31.96 | 30.41±1.40 | 719.86 | 77.79 |
| Summer, 1977 | May | 319.65 | 29.74–30.96 | 30.40±0.60 | 1103.15 (1.10 kg) | 83.83 |
| | June 30 | 416.64 | 27.85–28.29 | 28.46±0.84 | 1886.60 (1.89 kg) | 96.90 |

to high humidity. The feeding intensity is thereby believed to be affected more than it is during the less variable months of July and September; hence the wider range and lower mean for August.

*Growth rate and feeding of hatchlings.*

During the monsoon months, the mean weight and length of the hatchlings increased, the weight increase from 118.36 g to 393.22 g being progressive, the length increase from 36.94 cm to 63.14 cm not being regular (Table 1). In the first winter month (November) also an increase occurred; but in weight and not in length, being even greater than the increase recorded for October. During the two coolest months of December and January the mean weight (457.50 g and 455.23 g respectively) and length (65.42 cm and 65.33 cm respectively) was lower than that in November. But in February, the last winter month, an increase over that in January occurred raising both the weight (479.98 g) and length (65.51 cm). Despite negative growth in December and January, during the winter the mean weight and length increased by 86.76 g and 2.37 cm respectively (Tables 3, 4). Thereafter, during spring (March) and summer (April to June) both the weight and length increased progressively. Over a period of 12 months, the mean weight and length per hatchling increased respectively by 1768.24 g and 59.96 cm (Tables 3, 4); the percent seasonal increase is given in the Tables and shown in fig. 4.

Correlation of growth with feeding intensity (Fig. 2) shows considerable growth of the hatchlings during 7-8 months of vigorous feeding and, despite the low mean feeding intensity, in November also. Of the remaining four months, growth was negative in December and January when feeding intensity was low; it was slight in February, moderate in March when respectively the feeding intensity was slight and moderate.

*Growth of yearlings.*

During twelve months, the first year yearlings increased in mean weight and length by 4.86 kg and 48.73 cm, and the second year yearlings by 8.60 kg and 29.90 cm respectively (Tables 2, 3, 4). The increase in first year yearlings was progressive during monsoon (July to October) and spring-summer (March to June); in the intervening winter, November to February, the very slight increase in weight was progressive but the slight increase in length was not, because of a mean loss of 0.10 cm in December.

The second year juveniles increased progressively in mean weight during monsoon and spring-summer. In winter, a slight loss occurred in January and February; this is not normal because adequate quantities of fish could not be supplied and they probably metabolized the endogenous food reserve. Their length kept increasing progressively during monsoon and winter; but not during March (spring) as, despite a mean weight gain of 0.10 kg, a mean loss of 1.41 cm occurred. No explanation can be offered at present for this unexpected loss.

*Growth rate and ratio of hatchlings and yearlings.*

The annual growth rate (Tables 1, 2; Fig. 3) and growth ratio (Tables 3, 4) of hatchlings indicate an approximate increase by 16 times in weight and 2½ times in length; for first-year yearlings these increases are approximately 3½ and 1½ times respectively and for second year juveniles 2¼ and 1¼ times respectively.

Consideration of seasonal growth, as such and as % of annual growth (Tables 3, 4) of the hatchlings and yearlings shows weight gain in successive pre-winter seasons to increase

TABLE 2

MEAN MONTHLY GROWTH PER YEARLING FROM JULY, 1977 TO JUNE, 1979

| | Months and seasons | 1977-78, 1st year yearling | | 1978-79, 2nd year yearling | |
|---|---|---|---|---|---|
| | | Mean weight kg | Mean length cm | Mean weight kg | Mean length cm |
| | July 1 | 1.89 | 96.90 | 6.74 | 145.63 |
| | July | 2.23 | 102.88 | 8.33 | 145.67 |
| | August | 2.53 | 105.83 | 9.22 | 152.40 |
| Monsoon | September | 3.14 | 113.36 | 9.94 | 153.10 |
| | October | 3.24 | 114.54 | 10.08 | 154.67 |
| | November | 3.74 | 115.82 | 11.37 | 155.75 |
| | December | 3.75 | 115.72 (−0.10) | 11.48 | 155.76 |
| Winter | January | 3.79 | 116.42 | 11.36 (−0.12) | 156.40 |
| | February | 3.80 | 116.48 | 11.20 (−0.16) | 159.10 |
| Spring | March | 3.93 | 117.95 | 11.30 | 157.69 (−1.41) |
| | April | 4.87 | 118.52 | 13.23 | 160.76 |
| Summer | May | 6.10 | 130.72 | 13.65 | 166.69 |
| | June 30 | 6.74 | 145.63 | 15.34 | 175.53 |

and that in post-winter seasons to decrease concomitantly (Fig. 4). Length increment shows an opposite trend.

## DISCUSSION

The natural diet of *G. gangeticus* hatchlings and yearlings being unknown, they were fed on fish because their elongated snout with marginal teeth is an obvious adaptation for catching fish.

There appears to be no information on seasonal feeding activity and on growth, especially relative to food consumption, for crocodilian hatchlings. Even for adult crocodilians, only the seasonal feeding activity has been studied (Cott 1961, Joanen and McNease 1971), the other area having remained uninvestigated.

Hatchlings of *G. gangeticus* never ceased feeding in the first twelve months; only their food intake diminished greatly during winter months, showing a decrease in natural appetite with low temperature.

In contrast, captive yearlings and adults of *A. mississippiensis* in Louisiana, U.S.A. ceased feeding when water temperature was 60°F (=15.6°C) or less and air temperature 54°F (=12.2°C) or below, with the feeding spell extending for about eight months from mid-October till March (Joanen and McNease 1971). Field observations on juvenile and adult *A. mississippiensis* indicated feeding curtailment during periods of seasonally low temperature (McIlhenny 1935). The crocodile, *C. niloticus*, also refused food when air and water temperatures fell below 60°F (=15.6°C) (Pooley 1971). At the Kukrail rearing centre, the minimum water temperature during winter months being 22.7°C (January), was always considerably higher than 15.6°C, at and below which *A. mississippiensis* and *C. niloticus* ceased feeding. Consequently, non-cessation of feeding by *G. gangeticus* hatchlings during the

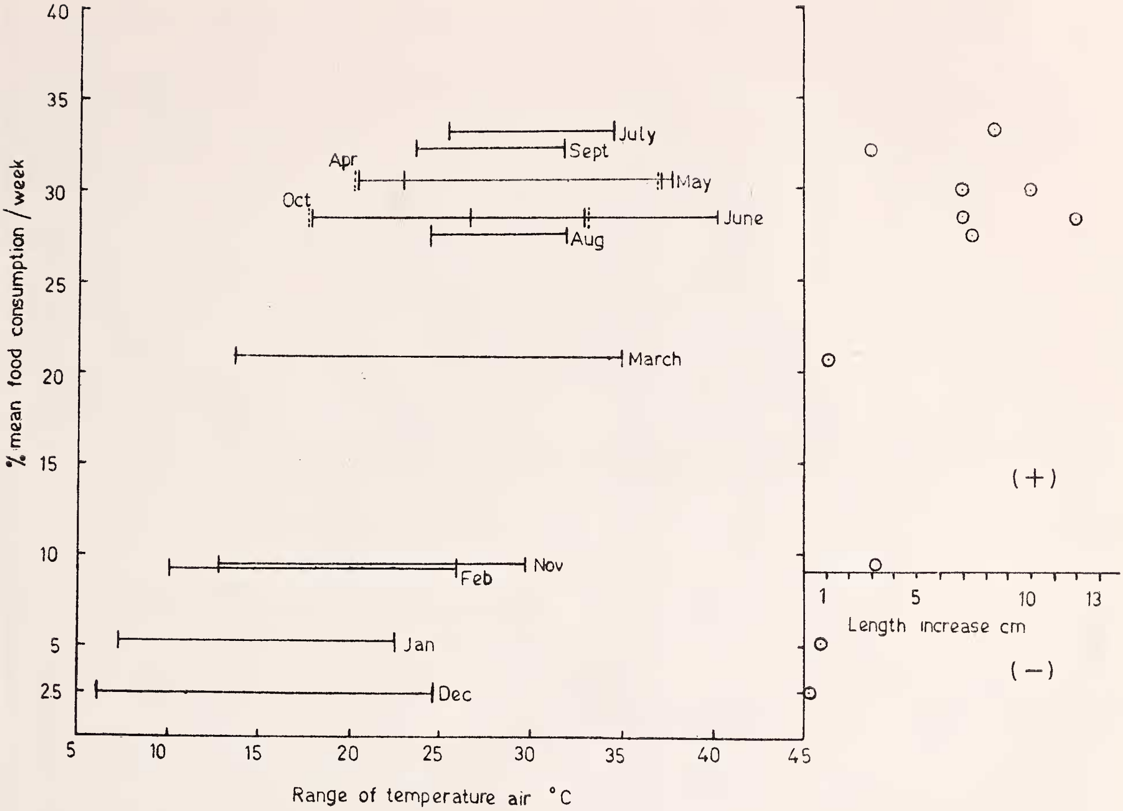

**Fig. 2. Temperature-food consumption and length increase relationship of hatchlings from July, 1976 to June, 1977.**

entire winter can be attributed to a milder winter in U.P. in subtropical India.

The hatchlings and yearlings grew during all the three seasons, monsoon, winter and spring-summer. Their growth during the eight months of monsoon and spring-summer was progressive and positive; during one or two winter months a slight loss in weight and in length did occur due, obviously, to metabolism of reserve food. However, being slight, the negative growth was offset by the total positive growth that occurred during the clement season. Since in February, the mean food consumption of *G. gangeticus* hatchlings rose to 9.18% body weight per week, and length registered slight increase, this quantity is taken to represent roughly the minimum quantum for fulfilling metabolic needs of the two coldest winter months, when growth is at its lowest.

However, what is not clear is the increase in length and weight of the hatchlings in November, despite low mean food intake of 9.45% body weight per week. A possible explanation is the reduced rate of metabolism, due to the cold, which permitted mobilization of all ingested food into endogenous reserve.

The closest parallel study on growth of newly hatched young is on *A. mississippiensis* hatchlings, produced in the second week of

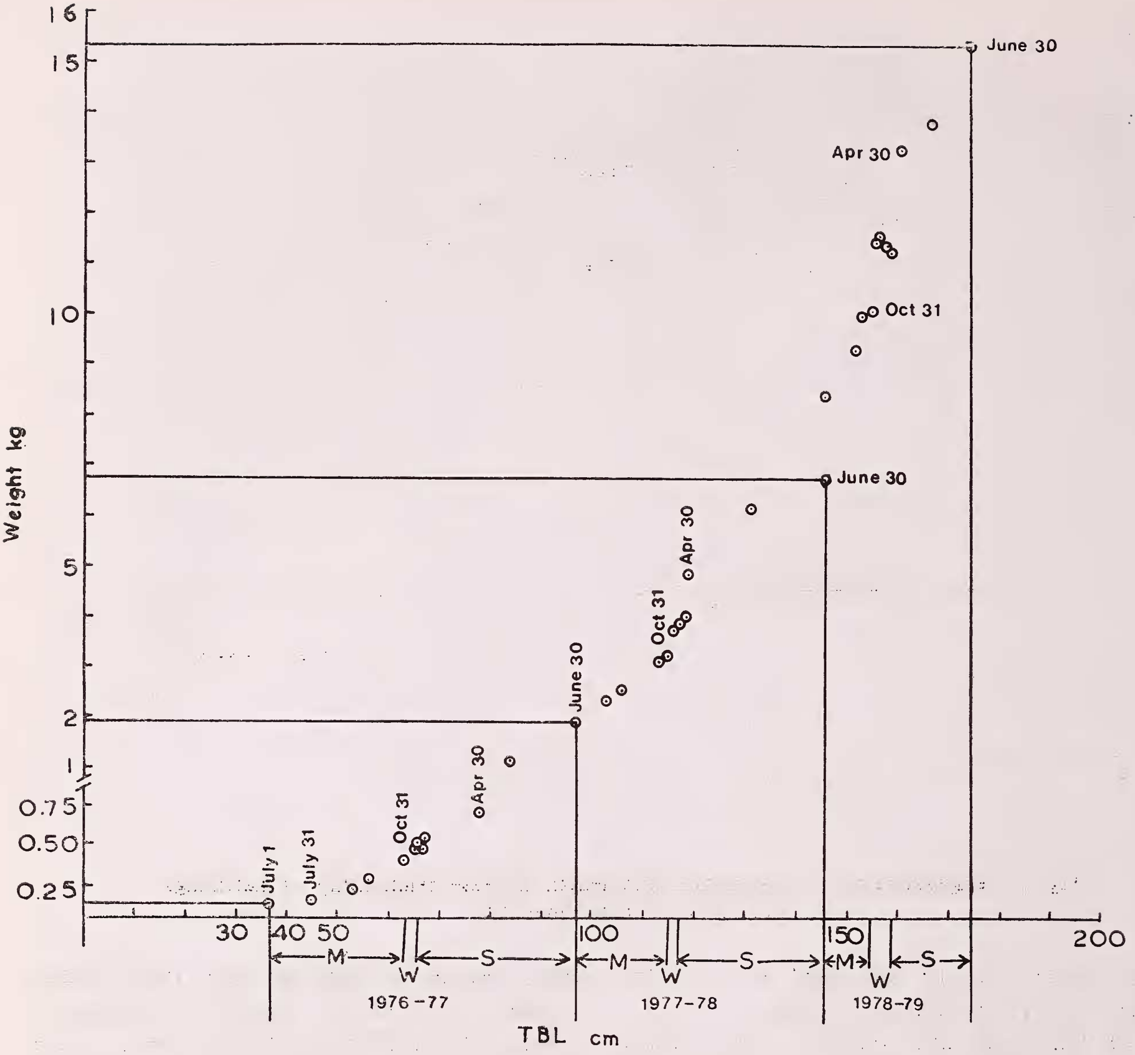

Fig. 3. Weight-length relationship of hatchlings and yearlings from July, 1976 to June, 1979. M, monsoon; W, winter; S, summer; TBL, Total body length.

September (Coulson *et al.* 1973) or in the third week, as determined from data of Goodwin & Marion (1978). According to Figure 2 (Coulson *et al.* 1973), the newly hatched alligator hatchlings were approximately 23 cm in mean length. They grew 69 cm in the first, and 41 cm in the second, twelve months, attaining respectively a mean length of 92 cm and 133 cm (Table 4). In the first six months, September to spring (March) 19 cm and in the next six months, March to September, 50 cm were added to the length of the hatchlings. This unequal growth is due to their arrival in September and passing of earlier life in inclement season, unfavourable for growth.

In contrast to those of the American alligator, the hatchlings of *G. gangeticus* are produced in June, about 2½ to 3 months

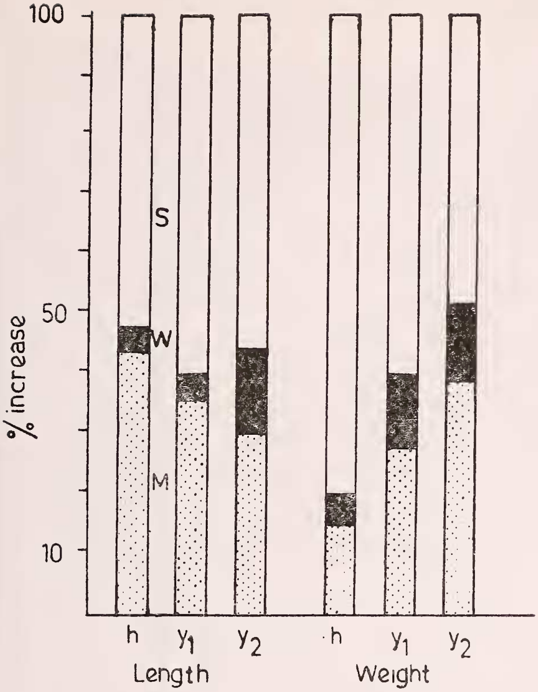

Fig. 4. Seasonal increase in length and weight of young for three consecutive years, from July, 1976 to June, 1979. H, hatchlings; $Y_1$ and $Y_2$, first and second year juveniles. M, monsoon; W, winter; S, summer.

earlier and are longer in mean length (36.94 cm). Incidentally, this mean length agrees well with 375 mm given for newly emerged gharial hatchlings (Smith 1931), but March/April, the given months of egg hatching are widely different. In their first twelve months, they increased slightly less (59.96 cm) than hatchlings of *A. mississippiensis,* yet they attained almost the same mean length (96.90 cm) as of the latter (92.00 cm). A break-up of this twelve-month growth shows an almost equal increment before (26.20 cm) and after (31.30 cm) winter. This is due to their arrival well before the winter, so that an equally long and favourable pre-winter period as the

TABLE 3

MEAN SEASONAL INCREASE IN WEIGHT PER HATCHLING AND YEARLING FROM JULY, 1976 TO JUNE, 1979

| Seasons and months | Hatchling | | 1st year yearling | | 2nd year juvenile | |
|---|---|---|---|---|---|---|
| | Weight increase g | Percentage | Weight increase kg | Percentage | Weight-increase kg | Percentage |
| Weight on July 1 | 118.36 (1976) | | 1.89 (1977) | | 6.74 (1978) | |
| Monsoon (pre-winter) July to October | 274.86 | 15.54 | 1.35 | 27.87 | 3.34 | 38.84 |
| Winter November to February | 86.76+142.33 − 55.57 | 4.90 | 0.56 | 11.60 | 1.11+1.40 −0.28 | 12.95 |
| Spring + Summer (post-winter) March to June | 1406.62 | 79.56 | 2.94 | 60.53 | 4.14 | 48.21 |
| Increase in 12 months | 1768.24 | 100.00 | 4.86 | 100.00 | 8.60 | 100.00 |
| Weight on June 30 | 1886.60 (1977) | | 6.74 (1978) | | 15.34 (1979) | |
| Growth ratio | 1:15.4 | | 1:3.52 | | 1:2.27 | |

TABLE 4

MEAN SEASONAL GROWTH IN LENGTH PER HATCHLING AND YEARLING FROM JULY, 1976 TO JUNE, 1979

| Seasons and months | Hatchling |  | 1st year yearling |  | 2nd year juvenile |  |
|---|---|---|---|---|---|---|
|  | Length increase cm | Percentage | Length increase cm | Percentage | Length increase cm | Percentage |
| Length on July 1 | 36.94 (1976) |  | 96.90 (1977) |  | 145.63 (1978) |  |
| Monsoon (pre-winter) |  |  |  |  |  |  |
| July to October | 26.20 | 43.69 | 17.64 | 36.19 | 9.04 | 30.23 |
| Winter |  |  |  |  |  |  |
| November to February | 2.37+3.41 –1.04 | 3.95 | 1.94+2.04 –0.10 | 3.98 | 4.43 | 14.81 |
| Spring + Summer (Post-winter) |  |  |  |  |  |  |
| March to June | 31.39 | 52.35 | 29.15 | 59.82 | 16.43+17.84 – 1.41 | 54.95 |
| Increase in 12 months | 59.96 | 99.99 | 48.73 | 99.99 | 29.90 | 99.99 |
| Length on June 30 | 96.90 (1977) |  | 145.63 (1978) |  | 175.53 (1979) |  |
| Growth ratio | 1:2.51 |  | 1:1.50 |  | 1:1.25 |  |
| ** *A. mississippiensis* young |  |  |  |  |  |  |
| Mean hatchling length on September 9 | 23.00 |  | 92.00 |  |  |  |
| Total length | 92.00 |  | 133.00 |  |  |  |
| Growth ratio | 1:4.00 |  | 1:1.44 |  |  |  |

** Data for *A. mississippiensis* taken from Coulson *et al.* (1973)

post-winter period, was available for feeding and growth.

Features of early growth worthy of note are: (1) maximum growth in the first year, (2) much lower weight gain in second relative to first year, and (3) increase in weight gain in pre-winter season and the concomitant decrease in post-winter season.

As in *G. gangeticus*, the two year data of Coulson *et al.* (1973) on *A. mississippiensis* also indicates greater growth in the first year of the alligator's life and the length ratio for the first and second years to be 1:4.0 and 1: 1.44 (Table 4). Comparison of the corresponding ratios (1:2.51 and 1:1.50) of the gharial shows that for the first year to be considerably lower. Yet the hatchlings of both had an almost equal mean length after twelve months (Table 4). This is due to the greater mean length of gharial hatchlings at birth.

Comparison of the other two features was not possible due to lack of corresponding data for other crocodilians.

## ACKNOWLEDGEMENTS

This research was supported by Wildlife Preservation Organization of Uttar Pradesh, Forest Department. I thank Dr. H. R. Bustard, ex-Crocodile Consultant to the Government of India, UNDP/FAO and Dr. B. K. Tandon, ex-Professor and Head, Department of Zoology, Lucknow University, Lucknow for their critical evaluation of the manuscript.

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